U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject: **ACTION**: Policy for 14 CFR §33.15, Materials

Date: January 21, 2004

From: Acting Manager, Engine and Propeller Directorate, Aircraft Certification Service

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Manager, Atlanta Aircraft Certification Office, ACE-115A
Manager, Airframe and Propulsion Branch, ACE-117A
Manager, Chicago Aircraft Certification Office, ACE-115C
Manager, Propulsion Branch, ACE-118C
Manager, Wichita Aircraft Certification Office, ACE-115W
Manager, Systems and Propulsion Branch, ACE-116W
Manager, Anchorage Aircraft Certification Office, ACE-115N
Manager, Transport Airplane Directorate, ANM-100
Manager, Transport Standards Staff, ANM-110
Manager, Airframe and Propulsion Branch, ANM-112
Manager, Seattle Aircraft Certification Office, ANM-100S
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Manager, Denver Aircraft Certification Office, ANM-100D
Manager, Los Angeles Aircraft Certification Office, ANM-100L
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1. Purpose.

This policy provides guidance for finding compliance with §33.15 of Title 14 of the Code of Federal Regulations (14 CFR §33.15), Materials. This policy establishes that when finding compliance with §33.15, ultrasonic (UT) billet inspection standards for titanium (Ti) material used in the manufacturing of engine rotating components should be considered. This policy applies to all classes of turbine engines governed by part 33.

2. Related Documents.

a. FAA Order 8110.4B, Type Certification Process, dated April 24, 2000.

b. Titanium Rotating Components Review Team Report, issued May 1991.

c. Society of Automotive Engineers (SAE) Document AMS 2628, Ultrasonic Immersion Inspection Titanium and Titanium Alloy Billet Premium Grade, issued October 1996.

d. Advisory circular (AC) 33.15-1, Manufacturing Process of Premium Quality Titanium Alloy for Rotating Engine Components, issued September 22, 1998.

3. Background.

a. In 1989, an in-flight separation of an engine Ti fan disk led to the fatal DC10 hull loss accident in Sioux City, Iowa. The Ti fan disk failure was attributed to the presence of a hard alpha material anomaly, which was introduced during the melt process and results from localized concentrations of interstitial impurities such as nitrogen, oxygen, or carbon. The anomaly was not found even though the UT inspection technique used at that point in time was commonly used by the aircraft engine industry. Due to this accident, the FAA established the Titanium Rotating Components Review Team (TRCRT) to review the design, manufacturing, inspection, and life management procedures of engine rotating parts and offer recommendations to improve their structural integrity. The TRCRT offered the following recommendations regarding the UT inspection of Ti billets and forgings in their May 1991 report:

- "For UT inspections of billets and semi-finish-machined disks, engine manufacturers should require the highest standard (smallest flat-bottomed hole (FBH) or equivalent) practicable in the industry for the size of the part being inspected. The following levels are considered to be practicable: 1/64 inch diameter FBH for billet ≤ 5 inches, 2/64 FBH for billet > 5 but ≤ 10 inches and (staying with) 3/64 FBH for billet > 10 inches. All semi-finish-machined disks (sonic shapes) should be inspected to a 1/64 FBH (or equivalent)."

- "Require the use and retention (according to the engine manufacturer's FAA-approved records retention schedule) of UT scan, strip charts or electronic equivalent for both billet and rectilinear, semi-finish-machined disks."

b. To address the TRCRT inspection recommendations, the FAA established the Engine Titanium Consortium (ETC) in 1993. The ETC consisted of representatives from Iowa State University, Honeywell, General Electric Aircraft Engines, and Pratt & Whitney. The ETC production inspection task concentrated on improved inspection of Ti billet. Two approaches to zoned inspection (multizone and phased array) were evaluated and improved to provide uniform sensitivity inspection at all billet depths. The ETC has demonstrated an approximate six-fold sensitivity improvement using the multizone system, compared to the FBH detectability of the conventional system.

c. Two engine manufacturers conducted implementation studies in the early 1990's, collecting "back-to-back" zoned and conventional inspection data. After analysis of the data, zoned inspection production facilities were established to inspect Ti billets. Zoned inspection of titanium billet material began in January 1995 for the two engine manufacturers. Currently, the U.S. has five zoned production inspection (multizone) systems, and Europe has one.

d. In October 1996, the SAE Committee K issued AMS 2628, which is an industry-wide specification for Ti billet UT inspection. In September 1998, the FAA, working with the Aerospace Industries Association (AIA) Structures and Materials Committee (SMC), issued AC 33.15-1. This AC, which describes the manufacturing processes for rotor grade Ti alloys, requires ultrasonic inspection of Ti billets but does not specify the inspection standards.

e. In the past several years, a variety of procedures and requirements have been in place in the aircraft engine industry for the UT inspection of titanium alloy billets. At least three engine manufacturers currently require zoned inspection, while others apply the conventional inspection used for the past twenty years. The FAA has developed this policy to establish a benchmark level of ultrasonic inspection sensitivity and to ensure inspection records are retained. This benchmark sensitivity level is consistent with the 1991 TRCRT recommendations and the SAE AMS 2628 billet inspection specification and has been achieved for over fifty percent of the Ti rotor grade billets produced for the aircraft engine industry over the past eight years.

4. UT Standards for Ti Billet.

The FAA, in cooperation with industry, has developed a multi-faceted strategy to improve the safety of high-energy rotors. This strategy includes improving the UT billet inspection of Ti alloys used to manufacture fan disks and other critical rotating engine hardware. The following standards implement this strategy:

a. Perform UT inspection of all Ti alloy billets that are less than or equal to 10 inches in diameter using a system with demonstrated inspection sensitivity equivalent to,

or better than, a #2 FBH at all billet depths. Perform the UT inspection in accordance with SAE Document AMS 2628 sections 3 and 4 or an equivalent FAA accepted procedure.

b. Perform UT inspection of all Ti alloy billets that are greater than 10 inches in diameter using a system with demonstrated inspection sensitivity equivalent to, or better than, a #3 FBH at all billet depths. Perform the UT inspection in accordance with SAE Document AMS 2628 sections 3 and 4 or an equivalent FAA accepted procedure.

c. Require the billet UT inspection system output to be electronic c-scan data, which can be acquired, retained, stored, and retrieved electronically.

5. Policy.

a. All Aircraft Certification Offices (ACO) and the Engine Certification Office (ECO) evaluating an applicant's compliance with §33.15 should consider the standards used by the applicant to identify the UT inspection requirements for Ti rotor billet material.

b. The ACOs and ECO should ensure that applicants demonstrating compliance to §33.15 include the necessary conformities by the appropriate Manufacturing Inspection District Office (MIDO), to ensure proper implementation of these requirements before design approval, in accordance with Order 8110.4B.

6. Effect of Policy.

a. The general policy stated in this document does not constitute a new regulation or create a "binding norm." Whenever an applicant's proposed method of compliance differs from this policy, it must be coordinated with the Engine & Propeller Directorate Standards Office, ANE-110, through the issue paper process or equivalent. In addition, if an office believes that an applicant's proposal that meets this policy should not be approved, that office must coordinate its response with the Engine & Propeller Directorate Standards Office, ANE-110.

b. Applicants should expect that the certificating officials will consider this policy when making findings of compliance relevant to new and amended certificate actions. This policy statement identifies one issue that will be considered when determining whether an applicant has shown compliance with §33.15, and offers one means, but not the only means, of showing compliance with the rule for that issue. The FAA, in appropriate circumstances, reserves the right to require that an applicant take additional actions in order to show compliance with the rule on this issue.

Original signed by FAF on 1/21/04
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